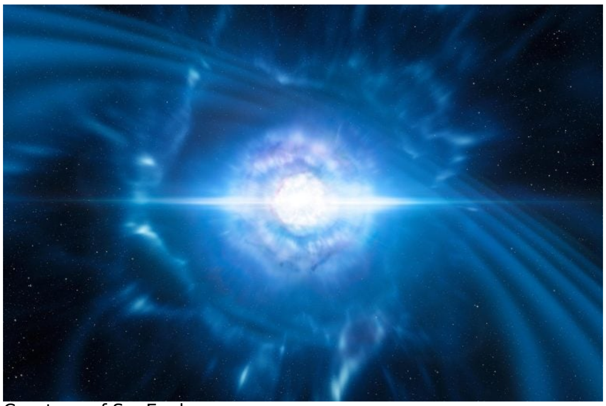
Secrets of Neutron Stars Unlocked by "Mirror" Nuclei

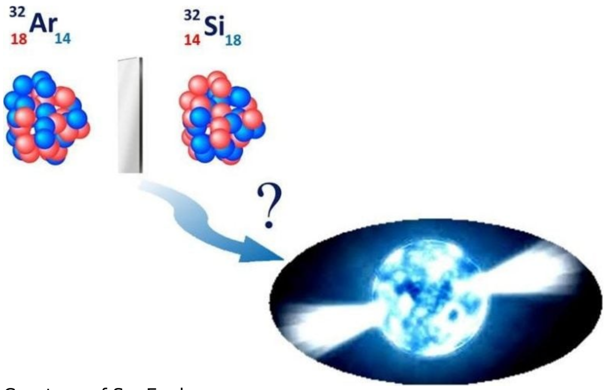
Posted by Okachinepa 09/30/2024



Courtesy of SynEvol
Credit: ESO/L.Calcada

The size of an atomic nucleus can be altered by adding or subtracting neutrons. Isotope shifts are the resultant minute variations in the energy levels of the atom's electrons. Researchers can determine an isotope's nucleus radius by precisely measuring these energy fluctuations.

In this study, the nuclear radii of the stable silicon isotopes silicon-28, silicon-29, and silicon-30 were measured with the aid of a laser. The unstable silicon-32 nucleus, which consists of 14 protons and 18 neutrons, was also measured in terms of radius. The researchers put constraints on variables that aid in describing the physics of astrophysical phenomena like neutron stars using the difference in radius between the silicon-32 nucleus and its mirror nucleus, argon-32, which contains 18 protons and 14 neutrons. The findings represent a significant advancement in nuclear theory, the study of nuclei and their constituent parts.



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Scientists continue to encounter persistent difficulties in their comprehension of nuclei, even with advancements in nuclear theory. For example, scientists have not made the connection between the strong nuclear force hypothesis and the description of nuclear scale. Furthermore, it's unclear if nuclear theories describing limited atomic nuclei can accurately characterize nuclear matter. The protons and neutrons that make up this unique kind of matter interact with one another. Extremely cold matter, like neutron stars, is considered nuclear matter. These unanswered concerns are addressed in part by precise measurements of charge radii, or the radius of atomic nuclei.

At the BEam COoler and LAser spectroscopy facility (BECOLA) at the Facility for Rare Isotope Beams (FRIB) at Michigan State University, researchers measured the nuclear radius of several silicon isotopes using laser spectroscopy measurements of atomic isotope shifts. The unstable silicon-32, which has 14 protons and 18 neutrons, as well as the stable silicon isotopes silicon-28, silicon-29, and silicon-30, were measured.

The outcomes offer a crucial reference point for the advancement of nuclear theory. The charge radii difference between the silicon-32 nucleus and its mirror nucleus argon-32, which has 18 protons and 14 neutrons, was utilized to limit parameters needed to characterize the properties of dense neutron matter within neutron stars. The reported results agree with the restrictions from gravitational wave observations and other complementing observables.